CHAPTER 9
CHARACTERISTICS OF WASTEWATER TREATMENT PLANTS AND GENERAL PLANT LAYOUT

9-1. Types of plants.

Wastewater treatment plants and processes have been classified as preliminary, primary, secondary, and advanced in chapter 3. A detailed outline of each process is provided in following chapters.

9-2. Elements of advanced wastewater treatment.

Advanced wastewater treatment encompasses several individual unit operations, used separately or in combin-ation with other processes, to achieve very high overall treatment efficiencies. These processes employ physical, chemical and biological treatment methods. The objective of advanced wastewater treatment is to improve the removal of suspended solids, organic matter; dissolved solids, and nutrients. The design details for advanced treatment unit operations are presented in chapter 15.

a. Polishing ponds. Polishing ponds are used to obtain increased organic and suspended solids removal efficiencies up to 20 percent from existing treatment. Treatment by polishing ponds can be aerobic (the biological activity is predominantly aerobic), or facultative (a combination of aerobic and anaerobic biological activity). Polishing ponds are also utilized to allow dissipation of chlorine residual to make discharge compatible with shellfish.

b. Post-aeration. Post-aeration applies when a certain effluent dissolved oxygen level must be maintained Post-aeration can be achieved by diffused aeration, mechanical aeration, or cascade aeration.

c. Microstraining. Microstraining is an effective effluent polishing device for removal of additional suspended solids and associated biochemical oxygen demand. The process consists of physical straining of solids through a screen with continuous backwashing, utilizing a rotating drum to support the screen. Static screens are also used in particular applications.

d. Filtration. Filtration is an effective method for achieving additional suspended solids and biochemical oxygen demand removal following conventional treatment processes. Filtration is also very effective as a part of phosphorus removal systems. Filtration can be applied directly to secondary effluents with or without sedi-mentation and pretreatment by chemical addition.

e. Adsorption with activated carbon. The primary function of carbon adsorption as a sewage treatment process is the removal of dissolved organics. This process can be applied as advanced treatment to adsorb non-biodegradable organics, or as a secondary treatment replacing conventional biological treatment. However, certain organics with small or highly polar molecules (e.g., methanol, formic acid, and sugars) are not removable by carbon adsorption.

f. Phosphorus removal. The basic phosphorus removal process consists of conversion of polyphosphates to soluble forms and then to insoluble forms, and subsequent separation of the insoluble phosphorus forms from the wastewater accomplished through chemical percipitation using lime or mineral additives such as alum or ferric chloride.. The process basically involves chemical addition, mixing, flocculation, and sedimentation.

g. Nitrogen removal. Methods for removing nitrogen from wastewater include air stripping, biological treatment, and breakpoint chlorination. Biological nitrification-denitrification appears to be the most practical alternative in most applications at this time. It involves the biological oxidation of ammonia to nitrate followed by anaerobic denitrifaction, with nitrogen leaving as nitrogen gas. Nitrification can be accomplished as a single stage combined with the activated sludge process or as a separate stage. Denitrification is a separate operation and can be of "suspended growth” or "attached growth” configuration. In this stage, nitrate is reduced to carbon dioxide, water and nitrogen gas following addition of methanol to provide the carbon source. Suspended-growth denitrification is an activated sludge-type operation with mixing but without aeration; attached-growth denitrification is a packed column process with attached biological growth on the packing media.

h. Land application. Land application of secondary treatment effluent can be used effectively as a means of phosphorous and nitrogen removal, biochemical oxygen demand removal, and solids removal. Since there is not a direct discharge to a receiving stream, land application in many instances is an attractive alternative for advanced treatment.

9-3. Plant site preparation.

Site drainage is an important factor in design of wastewater treatment facilities. Capacities of drainage structures will be designed in accordance with requirements of TM 5-820/AFM 88-5 series. All treatment units must be protected from surface rainwater by proper shielding and drainage.

9-4. Plant layout.

a. Arrangement of treatment units. The first step in determining the best arrangement of units is to arrange all units sequentially according to the flow of wastewater through the system. The resulting hydraulic profile for wastewater flow will determine the relative vertical alignment of each of the plant units. Final arrange-ment of the units then results from adaptation of site features to the treatment plant's functional and hydraulic requirements. Allowance must also be made for the area of operation and maintenance of the treatment units. If sufficient head is available for gravity flow, the hydraulic requirements will control the plant layout. Greater flexibility in arranging the treatment plant units is achieved with intermediate pumping of wastewater. The treatment plant must operate during emergency conditions such as power failures and also during periods of maintenance work on treatment units. Dual units should be provided in all feasible cases to provide operational reliability and flexibility.

b. Conduits and pipelines. Conduits and pipes will be arranged in such a manner as to reduce space and cost requirements. They will be designed to handle the expected maximum flows through the treatment plant. Design requirements for pipes and conduits are found in TM 5-814-1/AFM 88-11, Volume 1.

c. Bypasses and overflows. Provisions for bypassing individual treatment units will be made so that each unit can be taken out of service without interrupting the plant operation. Bypasses will not be provided for screen, chlorination units, nor other unit process where duplicate units are available. Overflows will be used to prevent hydraulic overloading of treatment units, especially biological treatment units. Return of flows or temporary storage of wastes not treated or alternate treatment must be provided. Refer to facility discharge permit for limitations on plant component bypasses and overflows.

d. Future expansion and flexibility. The plant designer will consider provisions for expansion by allowing sufficient space for additional units (and additional conduits) to be installed in the future. The plant will be designed so that installation of additional units or repair of existing units will not disrupt operations.

e. Treatment plant discharge. Outfall sewers will be extended to the low-water level of the receiving body of water or to submergence required by regulatory authority to insure satisfactory dispersion of the plant effluent. Provisions for effluent sampling and monitoring are required. The design will assure the structural integrity of the outfall, prevent failure due to erosion, and prevent back-flow during flooding.

9-5. Plant hydraulics.

a. Hydraulic loadings. The overall head allowances required for various types of wastewater treatment plants are shown in table 9-1.

Table 9-1. Head allowances.

Type of Plant	Head Required (feet)
Primary Treatment	3 to 6
Activated Sludge	3 to 6
Trickling Filters	
Low-rate with dosing tank	18 to 24
High-rate, single-stage	10 to 15

b. Limiting velocities. A minimum velocity of 2.0 feet per second at design average flow is required for channel flow. At minimum flows, a minimum velocity of 1.5 feet per second is required to prevent suspended solids from settling in flow channels.

c. Head loss. The total head loss through a treatment plant is the sum of head losses in the conveyance of wastewater between elements of the treatment process and the losses of head through treatment units. Head losses from wastewater conveyance are due to frictional losses in conduits, bends and fittings, and allowances for free-fall surface and for future expansions. TM 5-814-1/AFM 88-11, Volume 1, gives detailed guidance and charts for computing head losses in pipes and conduits. Head losses through process equipment are dependent on the specific units and are specified by their manufacturers or by the design engineer. The design engineer must consider hydraulic constraints in the layout and selection of process equipment and configurations. Special cases where dual and multiple pumping is required must receive prior approval by HQDA (CEEC-EB) WASH DC 20314-1000 for Army projects and HQ USAF/LEEE WASH DC 20332 for Air Force projects.

9-6. Plant auxiliary facilities.

a. General. A potable water supply will be provided. Sanitary facilities: toilet, shower and lavatory with hot and cold water supply, will be provided except for intallations with less than 0.1 million gallons per day capacity. The potable water line will incorporate an AWWA approved backflow prevention device to prevent the contamination of the water supply as required by TM 5-813-5/AFM 88-10, Volume 5. Emergency power for essential equipment will be provided. Adequate working and storage space is required for all plants. The general plant layout will facilitate operation and maintenance of the treatment units and their appurtenances.

b. Controls and monitoring. The plant arrangement will take into consideration the related control and monitoring requirements. Laboratory facilities will be provided for conducting the necessary analytical testing for the purpose of process control and compliance with regulatory or NPDES requirements. Appendix F lists required laboratory furniture, equipment, and chemicals for military installations. **Standard Methods for the Examination of Water and Wastewater** (current edition), as approved by the EPA, will serve as guidance in projecting these and additional laboratory needs.